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Chromosome Numbers in Fagus grandifolia and Quercus virginiana

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Chromosome Numbers in Certain Species of Helianthus

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BOOK REVIEWS

These papers are contributions No. 29 and 30, respectively, from the botany laboratories of Butler University. Address all communications regarding them to Butler University Botanical Studies, Butler University, Indianapolis, Indiana, U. S. A.

CHROMOSOME NUMBERS IN FAGUS GRANDIFOLIA AND QUERCUS VIRGINIANA

By HELLEN AUFDERHEIDE

INTRODUCTION

The chromosomes have been counted in a number of species of Fagaceæ, both in Europe and America. The opportunity now arises to add to the rapidly growing list one more species of Quercus and one species of Fagus whose numbers have not until now been determined.

Within the order Fagales, to which the genera Quercus and Fagus belong, Woodworth (13), 1929, determined 14 to be the reduced number in 17 species, varieties and hybrids of Corylus. The genus Betula has been found to contain polyploid forms with 14 as the basic haploid number (Wetzel (12), Jaretzky (7), Woodworth (13), (16), Helms and Jorgensen (5)), while Alnus has 14 as the basic number of a 2x and a 4x series (Woodworth (14), Jaretzky (7), Wetzel (12)). The Fagaceæ have been regarded as very regular indeed. In 1929 Wetzel (12) determined the chromosome numbers in *Fagus silvatica, Castanea sativa* and the following species of Quercus: *Q. cerris, Q. coccinea, Q. Dalechampii, Q. glandulifera, Q. Libani, Q. macranthera, Q. nigra, Q. Pontica, Q. Robur* and *Q. sessiliflora.* In each species he found the reduced number to be 11. Later, Jaretzky (7) took the same slides from which Wetzel (12) had made his counts. For every species studied Jaretzky (7) found 12 instead of 11 as the reduced number. Ghimpu (2) in 1929 reported 12 for each of the following species: *Q. cerris, Q. coccifera, Q. Ilex, Q. palustris* and *Q. suber.* Hoeegg (6) reported 12 chromosomes for *Q. sessiliflora, Q. robur* and *Q. suber Sno-Eg.*

In January, 1930, Friesner (1) published the results obtained from a study of the following ten species of Quercus: *Q. alba, Q. borealis, Q. coccinea, Q. macrocarpa, Q. marylandica, Q. Michanxii, Q. Muhlenbergii, Q. prinoides, Q. Prinus* and *Q. velutina.* His work was done on the root tips, the number determined being 12. In 1931 Tischler (11), in his "Pflanzliche Chromosomen-Zahlen," gave the reduced number for all the Fagaceæ, so far reported, as 12, stating in a footnote that Friesner (1) had made his counts correctly but that he had misinterpreted what he had seen, having mistaken the metaphase with its 24 chromosomes for the anaphase.

In the genus Carpinus the reduced number has been shown to be 8 in seven species and 32 in one variety (Wetzel (12), Jaretzky (7), Woodworth (16)). Three species and one variety of Ostrya (Wetzel (12), Jaretzky (7), Woodworth (16)) and one species of Ostryopsis (Woodworth (16)) each show 8 as the reduced number.

MATERIAL AND METHODS

Nuts of *Fagus grandifolia* were gathered October 18, 1930, at Trevlac, Indiana, and were planted in moist sawdust in the greenhouse October 20, 1930. On March 7, 1931, two nuts had germinated with roots long enough to be cut, while three nuts had roots too short to be of use. These were replanted. By March 14 four nuts had germinated with roots sufficiently long to be cut.

Acorns of *Quercus virginiana* were obtained December 30, 1930, at Allandale, Florida. They were planted January 3, 1931, in moist sawdust and set in the greenhouse to germinate. January 22, 1931, the seedlings had roots long enough to be cut. When the radicles from any particular seedling were long enough, they were removed and washed free of sawdust particles. The root tips were killed in Navashin's Killing Fluid, which consists of:

Part A—1 per cent chromic acid, 10 parts; glacial acetic acid, 1 part.

Part B—40 per cent formalin: 40 cc commercial formaldehyde; 100 cc distilled water.

Parts A and B were mixed in the proportion of 11:4.

Root tips were washed free from the killing solution, dehydrated and brought into paraffin. They were sectioned 10 microns thick and stained in iron hæmatoxylin. All chromosome counts were made with a Spencer research microscope equipped with apochromatic objectives and aplanatic condenser and at a magnification of 1900 x. Counts were made from both side and polar views of the metaphase and early anaphase stages of somatic mitosis.

OBSERVATIONS

Fagus grandifolia Ehrh. ($2x=12$). Figures 1 and 2 show polar views of the anaphase. Chromosome behavior is normal with 24 daughter chromosomes. Figures 3 and 4 show side view of the early anaphase.

Figure 4 shows an early anaphase with one lagging chromosome still in the equatorial plane. Figures 5 and 6 show polar views of the metaphase with chromosomes larger and fatter than those in the anaphase in Figures 1-4.

Q. virginiana Mill. (2x=12). Figures 7 and 8 show polar views of the anaphase with 24 chromosomes. Figures 9 and 10 show the early anaphase, side view, with 12 daughter chromosomes moving toward each pole. Figure 11 shows a polar view of the metaphase with 12 large, fat chromosomes in the equatorial plane. These are twice the size of those found in Figure 9. Figure 12 shows a side view of the metaphase with 12 large, fat chromosomes.

DISCUSSION

The low haploid number of 6 determined for 10 species of Quercus studied by Friesner (1) and one by the present writer, seems to be very significant, in view of the fact that Jaretzky (7), Ghimpu (2), Hoeegg (6) and Wetzel (12) found double that number in a number of species including two *(Q. alba* and *Q. coccinea)* studied by Friesner. If it were true, as Tischer (11) says, that Friesner (1) misinterpreted what he saw, mistaking the metaphase with its 24 chromosomes for the anaphase, cells should be found showing polar views of the anaphase with 48 daughter chromosomes. With this possibility in mind, the present writer has searched diligently for any such cells in her material. No cells were found showing more than 24 chromosomes in polar views. On the other hand, many cells were found showing polar views of the metaphase in which 12 larger and fatter chromosomes were scattered in the equatorial plane. There can be no doubt about these numbers, since repeated drawings of the same cells yielded the same numbers. Furthermore, these cells were entire cells, since the chromosomes could be focused entirely out of view without losing sight of the cytoplasm of the particular cell under study. If 12 were the reduced number, the metaphase should show 24 in such a view taken from root cells. Since 12 chromosomes were seen so clearly and distinctly in a large number of cells, the conclusion must be reached that the diploid number for the root cells of the species under study is 12 and not 24. If 12 were the reduced number, that number should not occur in any root cells at all. As further evidence that 12 is the diploid and not the haploid number for *Quercus virginiana,* side views of cells in both metaphase (Figure 12) and anaphase (Figures 9 and 10) stages are presented. Figures 9 and 10 show very clearly 12 chromosomes (and not 24) going to each pole of the dividing cell.

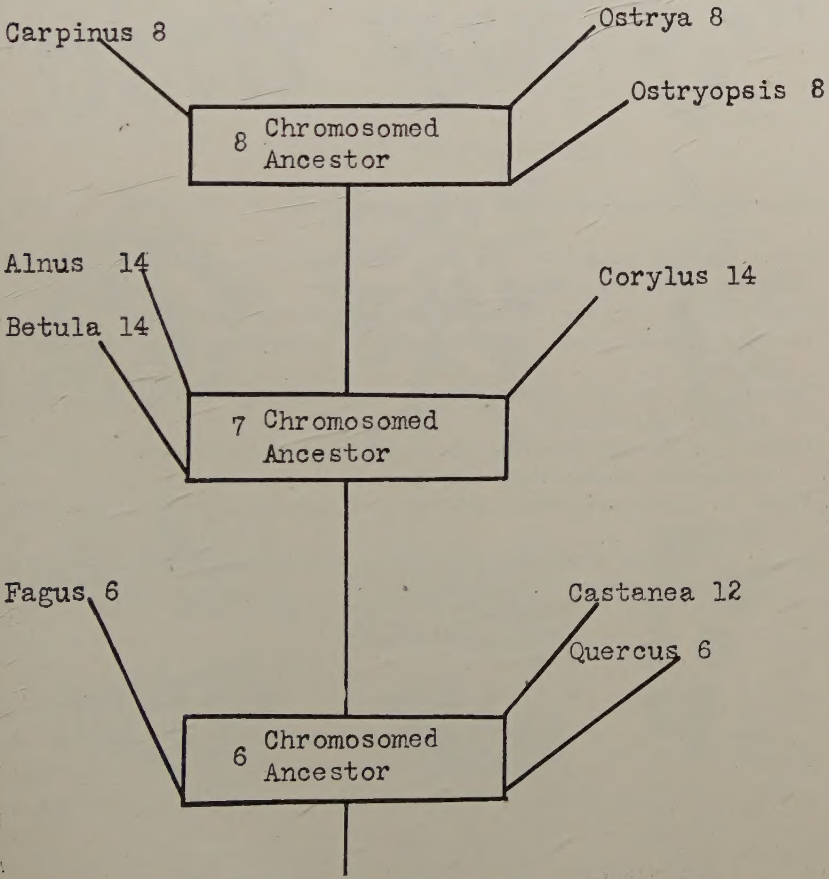
It is possible that polyploidy is present in Quercus as well as in Fagus, Alnus and Betula, and that the American species of Quercus have just half as many chromosomes as the European species. These are from different geographical sections of the world. Those made by Friesner (1) are from American material and those made by Kostoff and Kendall (8) and by Jaretzky (7) are from European material. It is entirely possible that American and European races of the same species have different chromosome numbers and that Tischler (11) is incorrect in his contention that Friesner's (1) interpretations are wrong, since Friesner's figures show polar views of metaphase plates with 12 chromosomes moving to each pole of the dividing cell. A careful re-examination of the preparations from which Friesner's (1) counts were made is now under way.

The same argument presented to support the view that 12 is the diploid and not the haploid number in Quercus is likewise applied to *Fagus grandifolia,* since the count given by Jaretzky (7) for *Fagus sylvatica* is twice the number found in the present investigation. The many clearly defined cells leave little doubt as to the number to be found or as to the interpretation.

If it is true, as it has been maintained by Osawa (10), Longley (9), Heilborn (7, 8) and others, that the lower the number of chromosomes possessed by members within any closely related group the more primative they are in respect to their phylogeny, then the genera Quercus and Fagus are more primitive than any other of the Fagales, since the basic chromosome numbers within the order are 6 for Quercus and Fagus, 8 for Carpinus and Ostrya, 12 for Castanea and 14 for Corylus, Alnus and Betula. Both Alnus and Betula contain polyploid forms, the former with tetraploid, pentaploid and hexaploid forms, and the latter with triploid, tetraploid, pentaploid, hexaploid and aneuploid forms. The basic number 14 for Alnus, Betula and Corylus may possibly represent a tetraploid form of a more primitive ancestor with 7 as the haploid number. Castanea with its haploid number 12 may likewise represent a tetraploid form of a more primitive ancestor whose haploid number was 6. This then would make a possible group of ancestral forms with 6, 7 and 8 as haploid numbers possible progenitors of the present members of the Fagales. The American members of the order are:

Fagales	Family Betulaceæ	Tribe I	Ostryopsis	8
			Corylus	14
			Ostrya	8
			Carpinus	8
		Tribe II	Betula	14
			Alnus	14
	Family Fagaceæ	Tribe I	Fagus	6
		Tribe II	Castanea	12
			Quercus	6

The following diagram will help to show a possible phylogeny of the probable progenitors of the modern Fagales.



SUMMARY

1. Chromosome studies reveal 12 as the diploid number of chromosomes in root cells of *Q. virginiana* and *F. grandifolia.*
2. Mitotic behavior is regular and normal in both species.
3. A diagram of the possible progenitors of modern Fagales is presented.

Grateful acknowledgment is made for helpful criticism given by Dr. R. C. Friesner during the process of this study.

EXPLANATION OF FIGURES

Figures 1, 2. *Fagus grandifolia:* polar view showing 24 chromosomes in early anaphase.

Figure 3. *Fagus grandifolia:* side view of early anaphase showing 12 daughter chromosomes moving toward each pole.

Figure 4. Same, with one chromosome lagging in the equatorial plane.

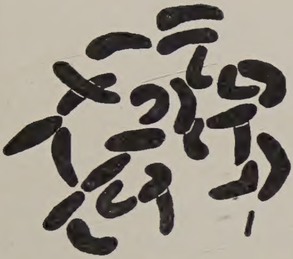
Figures 5, 6. *Fagus grandifolia:* polar view of metaphase showing 12 undivided chromosomes.

Figures 7, 8. *Quercus virginiana:* polar view of early anaphase showing 24 daughter chromosomes.

Figures 9, 10. *Quercus virginiana:* side view of early anaphase showing 12 daughter chromosomes moving toward each pole.

Figure 11. *Quercus virginiana:* polar view of metaphase showing 12 undivided chromosomes.

Figure 12. *Quercus virginiana:* side view of metaphase showing 12 undivided chromosomes in the equatorial plane.



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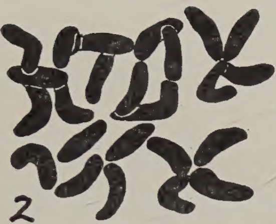

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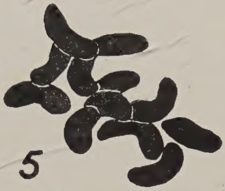

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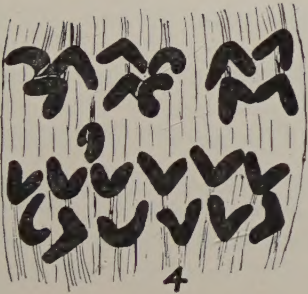

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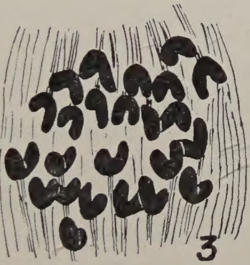

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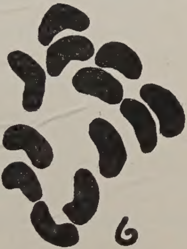

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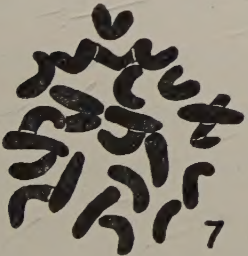

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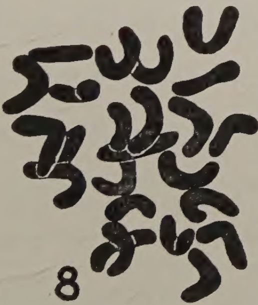

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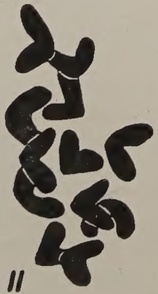

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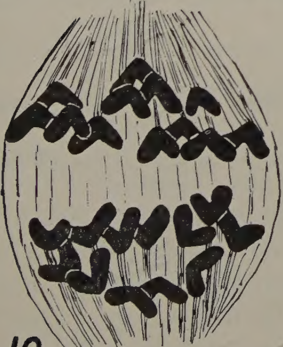

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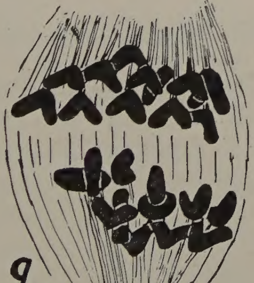

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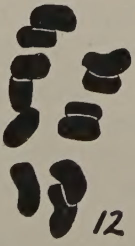

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LITERATURE CITED

1. Friesner, R. C. Chromosome numbers in ten species of Quercus, with some remarks on the contributions of cytology to taxonomy. Butler Univ. Bot. Stud. 1: 77-99. 1930.
2. Ghimpu, V. Sur les chromosomes de quelques chênes. Rev. Bot. appl. et Artic. Coloniale 9 (91) : 176-179. 1929.
3. Heilborn, O. Zur Embryologie and Zytologie einiger Carex-arten. Sv. Bot. Tidskr. 12 : 212-220. 1918.
4. ——— Chromosome numbers and taxonomy. Proc. Internatl. Congress Plant Sciences 1 : 307-310. 1926.
5. Helms, A., and C. A. Jorgensen. Birkene paa Maglemose Magle-mose i grib. Skov. VIII Kjobenhavn or Dansk. Bot. Tid. 39 : 57-155. 1925.
6. Hoeegg, E. On mellemformerne mellem *Quercus robur* L. og *Q. sessiliflora* Martyn. Bot. Tids. Copenhagen 40 : 411-427. 1929.
7. Jaretzky, R. Planta. 10: 120 *ff*. 1930.
8. Kostoff, Dontcho, and James Kendall. Zeitschr. f. Zellforsch. u. Mikroskop. Anat. 9 : 640 *ff*. 1929.
9. Longley, A. E. Cytological studies in the genera Rosa and Crategus. Amer. Nat. 57 : 568-569. 1923.
10. Osawa, J. Studies on the cytology of some species of Taraxacum. Archiv. Zellforsch. 10 : 450-469. 1913.
11. Tischler, G. Pflanzliche Chromosomen-Zahlen. Tabulæ Biologicæ Periodicæ 7 : 109-226. 1931.
12. Wetzel, G. Chromosomenstudien bei den Fagales. Bot. Archiv. 25 : 258-284. 1929.
13. Woodworth, R. H. Cytological studies in the Betulaceæ I. Bot. Gaz. 87 : 331-363. 1929.
14. ——— Cytological studies in the Betulaceæ II. Corylus and Alnus. Bot. Gaz. 88 : 383-399. 1929.
15. ——— Parthenogenesis and polyembryony in Alnus rugosa (Durai) Spreng. Science 70 : 192-193. Bot. Gaz. 89 : 402-408.
16. ——— Cytological studies on Betulaceæ IV. Betula, Carpinus, Ostrya, Ostryopsis. Bot. Gaz. 90 : 108-115. 1930.

CHROMOSOME NUMBERS IN CERTAIN SPECIES OF HELIANTHUS

By Florence Geisler

INTRODUCTION

The genus Helianthus is a comparatively large one, containing, according to Watson (13), 108 authentic and several doubtful species. These are arranged and classified by the taxonomist according to manifestations that are readily visible, but, if the chromosome number and the behavior during meiosis were known in each case, a better understanding could be gained of the interrelation of the species and greater accuracy might be possible in deciding whether a doubtful plant were a variety, a true species or a hybrid.

Up to now, the chromosomes have been counted in two species. Boenicke (1) reported 16 as the haploid number for *Helianthus annuus* L. in his work on the pollen mother cells. Tahara (11), Prozina (8) and Makowetzky (5), each working at different times on somatic cells of *Helianthus annuus* L., all gave 34 as the diploid number, which by inference would make the haploid number 17. Makowetzky's (5) study of the chromosomes of *Helianthus tuberosus* shows the haploid number to be about 51. The present paper adds seven more species of Helianthus whose chromosome numbers have hitherto not been counted.

Some work has also been done on a few of the other genera of the tribe Helianthea of the family Compositæ, to which the genus Helianthus belongs. Table I gives the results of all counts so far made in the tribe Helianthea.

MATERIAL AND METHODS

Material consisted of flower buds of the species of Helianthus included in this study. The first collections were made in the summer of 1929 and were gathered chiefly in the afternoon, the specific time of day not being noted. The material was recollected the following summer at the times and places indicated in Table II.

The young flower heads were cut in the field and stripped of their bracts. Then they were cut into several longitudinal pieces, which were

TABLE I

Chromosome Counts in the Tribe Helianthea

Genera	Species	Haploid Number	Diploid Number	Investigator		
Silphium	laciniatum L.	8	16	Merrell	1900	(6)
“	laciniatum L.	8	*16[1]	Land	1900	(3)
“	terebinthinaceum L.	8	*16	Land	1900	(3)
“	integrifolium Michx.	8	16	Merrell	1900	(6)
“	integrifolium Michx.	8	*16	Land	1900	(3)
“	perfoliatum L.	7	*14	Taylor	1926	(12)
Xanthium	inflexum	18	36	Symons	1926	(10)
“	italicum	18	36	Symons	1926	(10)
“	inflexum x italicum	18	36	Symons	1926	(10)
“	pennsylvanicum	18	36	Symons	1926	(10)
“	strumarium	18	36	Ishikawa	1916	(2)
Helianthus	annuus L.	16(?)	32(?)	Boenicke	1911	(1)
“	annuus L.	17	*34	Tahara	1915	(11)
“	annuus L.	17	*34	Prozina	1925	(8)
“	annuus L.	17	*34	Makowetzky	1929	(5)
“	tuberosus	ca. 51	ca.*102	Makowetzky	1929	(5)
“	orgyalis DC.	17	34	Present Paper	1931	
“	occidentalis Riddell	17	34	Present Paper	1931	
“	grosseserratus Martenas	17	34	Present Paper	1931	
“	giganteus L.	17	34	Present Paper	1931	
“	Maximiliani Shrad.	17	34	Present Paper	1931	
“	Maximiliani pallidi Clute	17	34	Present Paper	1931	
“	microcephalus T. & G.	17	34	Present Paper	1931	
Bidens	atrosanguinea	24	48	Lawrence	1929	(4)
Galinsoga	parviflora	18	36	Nawaschin	1925	(7)

[1] An * before a number indicates that work was done on somatic cells and that the haploid number was gained by inference only.

dropped immediately into chromo-osmic-acetic acid. The composition of the killing solution was as follows:

Solution A—1 per cent chromic acid, 15 parts; glacial acetic acid, 1 part.

Solution B—2 per cent osmic acid.

Solutions A and B were mixed as used in the ratio of 4:1.

The heads were allowed to remain in the killing solution twenty-four hours and then washed free of the fixative, dehydrated and brought into paraffin. When they were in 70 per cent alcohol, the pieces were divided into three groups according to the maturity of the heads, group one being the youngest. The heads were embedded so that both longitudinal and cross sections could be obtained. The heads were sectioned 10 microns, bleached with a 10 per cent solution of hydrogen peroxide and stained in iron hæmatoxylin. The number two's were sectioned first. If they did not show the stages desired, number one's or number three's were next used, according to whether number two was too old or too young. The counts were made by the use of a Spencer research microscope equipped with apochromatic objectives and aplanatic condenser and at a magnification of 1900. The stage of mitosis used was the anaphase, and, whenever possible, drawings were made of both first and second divisions in the formation of the pollen tetrads. Only the chromosomes in whole *(i. e.,* uncut) cells were used in making the counts. This was determined by focusing for cytoplasm both above and below the mitotic figure.

TABLE II

Showing Time and Place of Collection and Availability of Material

Species	Place	Time	Date	*Stage of Mitosis
H. orgyalis DC.	Botanical Garden	4:00 P. M.	8/10/30	Late anaphase
H. occidentalis Riddell	Botanical Garden	12:00 A. M.	8/12/30	Late anaphase
H. grosserratus Martens	Botanical Garden	6:45 A. M.	7/12/30	Early anaphase
H. giganteus L.	Waverly, Ind.	11:15 A. M.	8/12/30	Late anaphase
H. Maximiliani Shrad.	Botanical Garden	6:45 A. M.	7/12/30	Early anaphase
H. Maximiliani pallidi Clute	Botanical Garden	6:30 A. M.	7/12/30	Early anaphase
H. microcephalus T. & G.	Trevlac	1:15 P. M.	8/ 9/30	Late anaphase
H. decapetalus L.	Martinsville	4:00 P. M.	7/19/30	Late telophase
H. lætiflorus Pers.	Botanical Garden	11:45 A. M.	8/12/30	Late telophase
H. mollis Lam.	Botanical Garden	12:00 A. M.	8/12/30	Late telophase
H. tuberosus L.	Columbus, Ind.	7:30 A. M.	8/ 2/30	Early telophase
H. rigidus Cass.	Botanical Garden	12:15 P. M.	8/12/30	Telophase

*The stage of mitosis named for each species is the one that was best available for counting or the one that came nearest to being available. The meiotic stages were not suitable for counting the chromosomes in the last five species.

OBSERVATION

It was found that, in the flower heads collected in 1929, the meiotic mitoses were not in the right stages for chromosome counting. The flower heads were either too young or else in the early telophase, or had mature pollen grains with prominent spines. The material collected in 1930 was much better for the purpose desired. Seven of the twelve species collected showed stages of meiosis in which the chromosomes could be counted with a greater or lesser degree of accuracy. The stages found are indicated in Table II. The counts could most easily be made from the early anaphase.

Studying the sections as a whole, it was noted that in a longitudinal section of an anther, if one cell in a row were in a certain phase of mitosis, the other cells in that same row were also in about that same phase. However, flowers in the same head varied as to the stages of mitosis. Comparing the chromosomes of the first and second meiotic divisions, it was found that the chromosomes in the anaphase of the dyads were about twice the size of those in the anaphase of the tetrads. The dyads and the tetrads both contained the same number of chromosomes. In the anaphase of the first division, especially in the species which had the largest chromosomes, a very faint longitudinal split could be seen by careful focusing. Chromosome behavior appeared to be regular for the seven species studied.

H. orgyalis DC. ($x=17$). Figures 1 and 2. Both show 17 chromosomes. Figure 1 shows a polar view of the anaphase of one member of a tetrad. Figure 2 shows the polar view of an anaphase following reduction division. In both Figures 1 and 2 the chromosomes are short and thick, but the chromosomes in Figure 2 are about twice the size of those in Figure 1. The nuclear membrane had formed in both cases.

H. occidentalis Riddell ($x=17$). Figures 3 and 4. Both figures show 17 chromosomes. Figure 3 shows a polar view of a late anaphase following the second division. This was one of three visible in the same focus. Figure 4 shows a polar view of a late anaphase after the reduction division. The chromosomes are larger in Figure 4 than in Figure 3. The nuclear membrane was present in both figures.

H. grosseserratus Martens ($x=17$). Figures 5 and 6. Both figures show 17 chromosomes. Figure 5 shows an unusually clear polar view of an early anaphase following reduction division. The chromosomes are fat and curved. Figure 6 is a polar view of a late anaphase of the second division. The chromosomes are smaller than in Figure 5. The nuclear membrane is present in Figure 6.

H. giganteus L. ($x=17$). Figures 7 and 8. Both figures show 17

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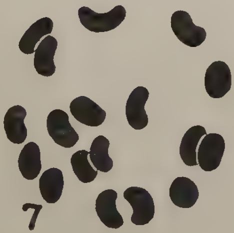
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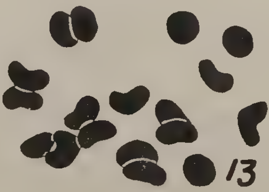
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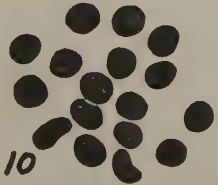
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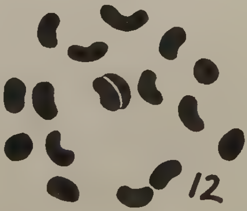
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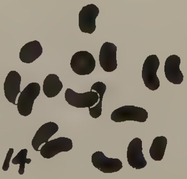
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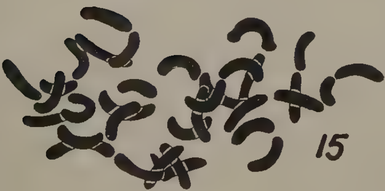
15

chromosomes. Figure 7 shows a polar view of an anaphase in the first division where the chromosomes are large and fat. Figure 8 shows a polar view of an anaphase in the second division where the chromosomes are smaller and not so thick as those in Figure 7.

H. Maximiliani Shrad. (x=17). Figures 9, 10 and 11. The chromosomes of this species are the largest of all those studied. Figures 9 and 10 show polar views of early anaphases just after reduction division. The chromosomes appear rounded and are well scattered. Both Figures 9 and 10 show 17 chromosomes, most of which are visible on one focus. Figure 11 shows the side view of an early anaphase of the reduction division with the chromosomes being pulled toward the poles. The chromosomes in this figure are scattered more than is customary at this stage. The spindle fibers are unusually clear. The figure shows 34 chromosomes.

H. Maximiliani pallidi Clute (x=17). Figures 12 and 13. Both show 17 chromosomes. The chromosomes are large. Figure 12 shows a polar view of a late anaphase of one member of a tetrad. Figure 13 shows a polar view of a late anaphase after the first division. The chromosomes are larger and thicker than in Figure 12.

H. microcephalus T. & G. (x=17) (2x=34). Figures 14 and 15. Figure 14 shows a polar view of a late anaphase following the second division and shows 17 chromosomes. The chromosomes are quite small and difficult to distinguish. No first division is on the available material. Several somatic cells on this slide showed mitotic figures, but the chromosomes in most of them are too densely massed for chromosome counting. Figure 15 shows a polar view of a somatic anaphase with 34 chromosomes. The chromosomes are longer and narrower than those of the reproductive cells.

DISCUSSION

Whether it could be definitely stated that it is best to collect the flowers of Helianthus in the early morning, if one wishes to obtain meiotic divisions in the right stages for counting, is doubtful, due to the small amount of evidence obtained. The results seem to point in that direction, as the best material was killed at 6:45 A. M. However, this was not the purpose of this paper and the data is presented in Table II for whatever it may be worth.

Judging by work already done, it appears that the basic chromosome number for the genus Helianthus is 17. Tahara (11), Prozina (8) and Makowetzky (5) found that number in *Helianthus annuus* L., and the present writer found 17 to be the haploid number in the seven species studied. Although Boenicke (1) reported 16 as the haploid number for *Helianthus annuus* L., the weight of evidence is against him. Polyploidy is evidently present in the Helianthi, since Makowetzky found the haploid number of *H. tuberosus* to be about 51, which would make this species a hexaploid.

Since both dyads and tetrads contain 17 chromosomes, reduction apparently takes place during the first meiotic division, when the pollen mother cell divides to form the dyads. Since the size of the chromosomes in the second division is about half that of those in the first division, the second division is an equational mitosis where each chromosome splits in half. The line of splitting for the second division is already determined in the anaphase of the first division, according to Sharp (9).

So little work has been done on the tribe Helianthea that any suppositions as to the possible phylogeny could not be accurate. However, it is interesting to note that Silphium with 8 has the lowest basic number yet found. Helianthus is next with 17, Xanthium and Galinsoga with 18 and Bidens with 24.

Assuming that, in a tribe or genus, the members with smaller chromosome numbers are more primitive than those with larger numbers, then the ancestor of the members of the tribe Helianthus probably was an 8 chromosomed form which gave rise to Silphium. Through changes which affected the number of chromosomes in the reproductive cells, the other genera could have arisen from this primitive form. Failure of reduction division or reduplication of all the chromosomes through splitting might have given rise to a form with 16 chromosomes. The reduplication of one or two chromosomes of the form with 16 could account for the ancestor with 17 which gave rise to Helianthus, and the form with 18 from which Galinsoga and Xanthium developed. Nondisjunction is another possible cause of the formation of 17 chromosomes from 16. The ancestor of Bidens with 24 chromosomes could have been evolved by the crossing of a form whose reduced chromosome number is 8 with one whose reduced number is 16. Then 24 as the reduced number could become a constant factor if, during meiosis in this individual, reduction division failed or there was a reduplication through splitting.

The following diagram indicates the possible phylogenetic arrangement of the genera whose chromosome numbers have been studied in the tribe Helianthea.

Yet, the chromosome numbers alone are not sufficient evidence for grouping related genera. Although Galinsoga and Xanthium both have 18 as their reduced chromosome numbers, their gross structure is so different that they cannot be considered so closely allied as the cytological data may appear to indicate.

Much work remains to be done on the genus Helianthus, and further investigations as to the chromosome numbers may lead to interesting conclusions.

SUMMARY

1. Flowers killed in the early morning seem to be better for obtaining the stages of meiosis suitable for counting the chromosomes than those killed in the afternoon.
2. All cells in the same row in an anther undergo the same phases of mitosis simultaneously.
3. The chromosomes of the first division are twice the size of those in the second division.
4. Chromosome behavior is regular for the seven species studied.
5. Reduction division takes place at the first division.
6. The reduced chromosome number is 17 for the following species of Helianthus: *H. orgyalis* DC., *H. occidentalis* Riddell, *H. grosse-serratus* Martens, *H. giganteus* L., *H. Maximiliani* Shrad., *H. Maximiliani pallidi* Clute and *H. microcephalus* T. & G.

The writer wishes to thank Dr. R. C. Friesner for suggesting this problem, collecting the material, and for his many helpful suggestions for working out this study.

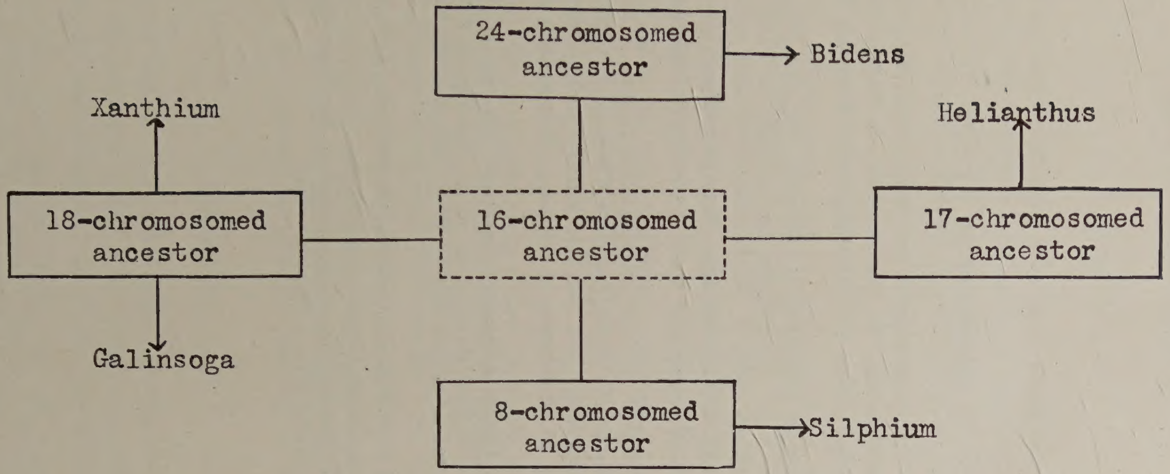

DIAGRAM OF POSSIBLE PHYLOGENY WITHIN THE TRIBE HELIANTHEA

LITERATURE CITED

1. Boenicke, L. Von. Zur Kenntnis der Prophasen der heterotypishen Teilung einiger Pollenmutterzellen. Ber. Deut. Bot. Ges. 29 : 59-65. 1911.
2. Ishikawa, M. A. A list of the number of chromosomes. Bot. Mag. Tokyo 30 : 404-448. 1916.
3. Land, W. J. Double fertilization in compositæ. Bot. Gaz. 30 : 252-260. 1900.
4. Lawrence, W. J. C. The genetics and cytology of Dahlia species. Jour. Genetics 21 : 125-159. 1929.
5. Makowetzky, M. Trud. Ssilsk. Gost. Botan. Charkiw. 2 : 211 *ff*. 1929.
6. Merrell, W. D. A contribution to the life history of Silphium. Bot. Gaz. 29 : 99-133. 1900.
7. Nawaschin, M. Zs. f. Zellforsch. u. mikroskop. Anatom. 2 : 98 *ff*. 1925.
8. Prozina, M. Recherches caryologiques sur le Tournesol. I. Division somatique chez *Helianthus annuus*. Jour. Soc. Bot. Russie 9 : 63-68. 1925.
9. Sharp, L. W. An introduction to cytology. McGraw-Hill Book Co. New York. 1926.
10. Symons, F. L. Studies in the genus Xanthium. Bot. Gaz. 81 : 121-146. 1926.
11. Tahara, M. Cytological investigation on the root-tips of *Helianthus annuus*, with special reference to the behavior of the nucleolus. Bot. Mag. Tokyo 29 : 1-5. 1915.
12. Taylor, W. R. Chromosome morphology in Fritillaria, Alstrœmeria, Silphium, and other genera. Amer. Jour. Bot. 13 : 179-193. 1926.
13. Watson, E. E. Contributions to a monograph of the Genus Helianthus. Mich. Acad. Sci., Arts and Letters 9 : 305-475. 1928.

BOOK REVIEWS

BIOLOGY

Hunter[1] in his recent textbook, "Problems in Biology," has brought the fruits of pedagogical research to textbook application in the selection and presentation of biological material for the high school pupil. The book is truly biological and not merely partly botanical and partly zoölogical. The material is presented in five parts. Part 1 deals with living things in relation to each other and their surroundings. Part 2 presents green plants as the manufacturers of the food of the world. Part 3 considers relationships and inter-relationships of living things. Part 4 considers the biology of man and Part 5 deals with the interrelations between man and other living things. Each part is further subdivided into a number of units and the various units are presented in the form of definite problems. Each unit is introduced by a survey of the work to follow and each problem is concluded by a "self-testing exercise." The material is presented in a style and on a plane well within the grasp of the high school pupil. In the treatment of the cell it is unfortunate that mitosis and amitosis are both presented, especially since they are so presented as almost certainly to lead the pupil to conclude that the former is characteristic of animals and the latter characteristic of plants. The book is concluded with a glossary of important technical terms and a valuable appendix. The author has made a distinct contribution to the science textbook field and a real service to the teaching of biology. The publishers, likewise, have done their part of the work well. In spite of the fact that there are over 700 pages, the book is not large, even though the print is unusually readable.—R. C. F.

ECOLOGY

The revision of Volume 3 of the Coulter, Barnes and Cowles' texts[2] has recently come from the press. The organization and treatment of material has in the main followed that of the first edition. Changes of material have been made in old topics and some new topics added where necessary to bring the text up to date. Important among these are considerations of "xeromorphic leaf structure," a treatment of "life forms of stems" and "biological spectra" and presentation of some of the main results of studies in "photoperiodism." Among the old topics in which considerable change was necessary to "modernize," the reviewer noted especially the material on "sex determination." All of our information regarding visible chromosome differences between sexes of plants has appeared in print since the first edition of this book, likewise much of our present conception of sex as a "physiological state." In the treatment of "sexuality in the fungi," it is surprising to note no reference to the recent work of Buller and his students. A most valuable addition is found in the well organized bibliography which brings the very latest references to the attention of those who wish more than can properly find a place in the volume. Dr. Fuller has done his work very well and it is to his credit as well as a tribute to the spirit and organization of the volume by the original author, Dr. Cowles, that so little change was necessary over twenty years after the first edition made its appearance. It is likewise a real achievement on the part of the publishers to produce a product so excellent in workmanship at so reasonable a price. —R. C. F.

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[1] Hunter, George W. Problems in Biology. pp. XII+706. New York: American Book Co. 1931.

[2] Coulter, John M., Charles R. Barnes and Henry C. Cowles. A Textbook of Botany for Colleges and Universities. Vol. 3, Ecology. pp. X+499. fig. 541. New York: American Book Co. 1931.

TAXONOMY

In "Common Names of Plants," Clute[3] has opened a storehouse of botanical information and plant-lore to the layman. In the volume many of the common names applied to the familiar plants of fields and woods are unraveled. As pointed out by the author, the common names were in many cases the first names applied by those who had practical, every-day experience with the plants, and in most, if not every case, they had some logical connection with properties of the particular plant.

To the professional botanist this little volume is a bit of relaxation and its effects are exhilarating. He can return to his class in taxonomy with a new feeling for the significance of all plant names, and marvels at the ability of the author to give so much technical information so well shorn of its visible technical forms.—R. C. F.

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[3] Clute, W. N. Common Plant Names. pp. VI+160. Indianapolis: Willard N. Clute and Co. 1931.